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Summary report of the turboprop test chamber acceptance tests conducted on 27 April to 8 May 1964

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Astro/Aeronautical Propulsion Laboratories

SUMMARY REPORT

of the

TURBOPROP TEST CHAMBER ACCEPTANCE TESTS

Conducted on

27 April to 8 May 1964

Prepared ____________________
Staff Engineer

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ABSTRACT

Acceptance testing of the Turboprop Test Chamber was conducted during the weeks of 27 April and 4 May 1964. The tests were conducted by personnel from the Overhaul and Repair Department, Alameda Naval Air Station, from the Bureau of Naval Weapons Fleet Readiness Representative, Pacific and from the USNPGS Department of Aeronautics. The power plant utilized for correlating purposes for a T-56-10W turboprop engine, recently overhauled at NAS Alameda while the propeller was the Hamilton Standard model required for this engine.

The test data reveal satisfactory correlation of the engine performance data with the Alameda test results. The discrepancies that do appear are the result of errors in the instrumentation system and do not present a major problem. All of the major facility systems function satisfactorily except the oil supply system and the chamber lighting fixtures. Engine starting and control systems were adequate although somewhat different from the designs utilized in the NAVWEPS specifications for this engine.

The engine support stand and thrust measuring assembly were found to be structurally sound and functioned satisfactorily. The propeller orifice assembly did not induce prohibitive vibrational stresses as was anticipated. However, the vibrational loads did cause the majority of the orifice retaining bolts to loosen during the test sequence. Three bolts were found beneath the test stand; these could have caused object damage to the engine.

The major areas of discrepancy are the engine oil supply system and the test chamber lighting fixtures. The engine oil system as

designed could not satisfy the requirements for the T-56 series engine. It was necessary to re-route the oil by-pass system, to obtain a more precise control of the engine oil supply and pressure, and to provide a method to heat the oil for operation of the engine at high power settings. The system as temporarily modified, did function adequately during the test period.

The lighting fixtures mounted on swivel joint bases oscillated violently when operating the engine at Idle power. One fixture above the engine broke loose during this short period and was blown clear of the engine stand by the propeller air stream. All ceiling-mounted light fixtures were removed from the chamber before further engine operation.

The acoustic survey revealed that the acoustic paneling in the inlet and the exhaust passages functioned satisfactorily. However, the Sound Pressure Level reduction across the chamber front double-doors did not meet the specified limits.

Corrective action is required to (1) provide adequate and safe lighting in the test chamber, (2) re-design and install an oil supply system compatible for operation with the T-56 engine, and (3) provide positive locking devices on <u>all</u> bolted fixtures in the test chambers.

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Introduction

In accordance with NAVDOCKS Specification 39189/61 and S-T18b, acceptance testing of the turboprop engine test facility was conducted to evaluate the operability, accuracy and maintainability of the complete test facility and all associated equipment. The basic configuration of the test complex is shown in Figures 1, 2, 3, and 4 in Appendix II. Actual test conditions were obtained by operating a T-56-10W turboprop engine equipped with a Hamilton Standard propeller. This powerplant had recently been overhauled and tested at the U. S. Naval Air Station, Alameda, California.

The fabrication and installation of the test harness were accomplished by personnel from the Overhaul and Repair Department, NAS Alameda; the calibration of the facility instrumentation was conducted by the Metrology Field Team from the same station. The test program was directed by the USNPGS Aeronautics Department with the consent of the Resident Officer in Charge of Construction. The acceptance tests were conducted during the weeks of 27 April and 4 May 1964. The tests were witnessed by the aforementioned personnel as well as by representatives from the construction contractor, the design contractor, the 12th Naval District Public Works Office and the Bureau of Naval Weapons Fleet Readiness Representative, Pacific. A complete list of the attendees is presented in Appendix I.

Test Preparation

The initial preparation for the acceptance testing was an onsite survey of the facility by the representatives from the Overhaul and

Repair Department, Alameda on 27 September. It was the conclusion of this inspection team that the facility configuration was not satisfactory for safe operation of a T-56 engine. The specific discrepancies presented in Appendix II, reference (a), were reviewed by this activity with the aide of the engine and propeller manufacturer's engineering representatives. The problem areas and the corrective action taken before and during the acceptance test period, prior to engine operation are summarized as follows:

(a) The Low-speed Ground Idle Switch, as installed, was not a solenoid holding type switch as specified in reference (b). The contractor installed the proper switch before the acceptance tests.

(b) The Manual Phase and Trim Assembly, which is an integral part of the propeller synchrophase system, was not initially furnished by the contractor. However, this unit was procured by the contractor along with the synchrophase unit and was installed by the Alameda personnel before the acceptance tests. Both units are shown in Figure 5.

(c) The Propeller Master Trim Switch was not provided in the original configuration. The contractor installed this unit before the test period.

(d) The Propeller Re-synchronize Switch and the necessary circuitry was not included in the original installation. The contractor added this function before the acceptance tests.

(e) The Temperature Trim Warning Indicator for the T-56-7 engine was not provided. The contractor has agreed to install this small circuit after the acceptance tests.

(f) The Starting Temperature Limit Check Switch was not installed in the initial configuration. The switch was incorporated by the contractor before the acceptance tests.

(g) The Condition Lever did not contain two cam-operated switches in the original design. One switch is for control of the engine electrical power, while the other is for feather operation of the propeller. Since these two switches were provided on the console, although not as an integral part of the condition lever control, no change was requested by this activity.

(h) The Power Lever Position Indicator could not be read to within the desired 1° increments, therefore it was necessary to use a dial from the turbojet console. The contractor furnished an expanded dial after the acceptance tests.

(i) It was desired that the fuel shut-off valve in the test chamber be linked with the propeller feather operation for emergency shut-down. It was decided that this feature is duplicated by the Fuel-to-Engine Switch and the interconnection to the fire protection, CO_2, system. Thus this change was not incorporated by this activity.

(j) The Servo Control Isolation Switch was not provided in the initial design. The contractor installed this "propeller governor" switch prior to acceptance testing.

(k) No provision was made in the facility electrical system design to provide 208V, 3 phase, 400 cycle power for driving the propeller feather pump motor. A portable power generating unit, shown in Figure 6, was borrowed from NAS Alameda for the duration of the acceptance tests.

(l) The Engine Oil Supply System is shown in Figure 7, and was found to be completely inadequate for use with the T-56 series engine. The Alameda survey revealed that the oil returning from the engine would experience excessive back pressure from the by-passed oil being circulated by the pump. Thus it was necessary to re-route the lines in this area, as shown in Figure 8. This re-arrangement was performed by this activity before the acceptance tests. It was also believed that the pump capacity in the system was too large and would not be adjustable to permit the lower supply pressures required. This activity simulated the engine system with an orifice meter and found that adequate flow rates could be obtained, but the supply pressure to the engine could not be reduced below 9 psig. This condition was marginally acceptable since the oil inlet pressure is normally in the 5 psig range.

The possibility of excessive foaming of the return oil was discussed during the Alameda survey. Since the amount of foaming caused by the turbulent action of the oil in the propeller gear box was unknown, a stand-by method of de-airation was obtained for this test period.

The predominate oil system problem,disclosed by Alameda personnel, which could not be completely verified until actual operation of the engine, was the need for complete control of the temperature of the oil entering the engine. A heat exchanger, shown in Figure 8, was provided in the facility to cool the oil returning from the engine and the gear box; however, no provision was made to heat the oil if excessive cooling took place in the extensive piping system during engine operation. This excessive cooling problem due to the long lengths of line being exposed to the propeller air stream had been encountered and corrected at test facilities at NAS Alameda and at the engine manufacturer's plant. This activity attempted to duplicate the engine "heat source" and to verify the presence of such a cooling problem. The test results were inconclusive since the propeller air stream could not be duplicated. In order to not delay the acceptance tests with extensive re-work, the system was assumed to be operable and sufficient for testing the T-56-10W engine, at least in the lower power range where the oil inlet temperature requirement did not apply.

(m) The Alameda survey questioned the structural adequacy of the lighting fixtures in the test chamber. All of the overhead lamps, shown in Figure 9, extended approximately three feet below the overhead and would be subject to the propeller air stream. The extensions were mounted in "ball joint" bases which would allow the fixtures to swing freely in this high velocity air stream. A change order was completed which removed the extension arms on all fixtures directly above the engine and attached the lamps directly to the ball joint bases. This modification was completed by the contractor in November 1963.

(n) Measurement of the orifice diameter disclosed that the minimum spacing between the propeller tip and the orifice surface was approximately two inches, which is less than the limit suggested in Appendix II, reference (b). The data also revealed that the orifice was not circular. Thus concern was raised as to whether the variance in tip spacing would induce excessive vibrational loads on the engine, propeller and the supporting assembly. Data furnished by the propeller manufacturer indicated that safe operation of this model propeller could be realized if the trailing edge of the blade, in full feather position, was forward of the orifice plane. The engine support stand was re-located to attain this axial positioning. It was agreed that close monitoring of the vibration levels of the gear box engine and support stand would be necessary throughout the acceptance tests.

(o) It was noted that the operation of the engine in the "full feather" position or in the transition from forward to reverse pitch could cause a stagnation of the engine exhaust gases. The resulting overheat condition could trigger the CO_2 system and severely damage the engine. The use of an exhaust duct which would separate the engine discharge airflow from the propeller air stream is normally provided in turboprop test chambers. However, since this unit was not provided, this activity installed thermocouples near the CO_2 detector units in the test chamber in order to closely monitor the temperature rise when operating the engine in these critical regions.

(p) The vibration pickups furnished by the contractor were Consolidated Model No. 4-103, which could not be used for testing the T-56 series engine. Reference (c) in Appendix II requires that Model No. 4-106 be utilized for T-56 testing. In addition, two plug-in filters, (15 cps and 150 cps), should have been incorporated in the Vibration Meter, Model No. 1-117, which is installed on the control console. NAS Alameda agreed to furnish these components for the acceptance test period.

In addition to the above corrective action, this Department modified the rear overhead support mount, shown in Figure 10, to reduce the freedom of movement of the engine in the plane perpendicular to the engine centerline.

Figure 11 reveals the instrumentation duct which was fabricated and installed to protect the electrical lines and control leads from the propeller air stream.

The orifice assembly was modified as shown in Figure 12 to gain easier access with the chain hoist to both the front and the rear areas of the test chamber. The original design made it necessary to completely remove the top center section to install the engine or the propeller.

The complete instrumentation system in the turboprop chamber had been calibrated by the Metrology Field Team from NAS Alameda in December 1963, during the acceptance testing of the adjacent turbojet test cell. The thrust load cell, the force indicators and the vibration pickups had been evaluated at NAS Alameda Metrology Laboratory at that time.

Test Sequence

The Production Engineering field team from NAS Alameda arrived at USNPGS on 27 April and began the installation of the engine test harness, the associated controls and engine instrumentation. The facility systems to be used during the acceptance testing were reviewed again for adequacy and for safe operation of the engine and propeller. Continuity check of the electrical and instrumentation systems were conducted and modifications were made where necessary.

The engine was "motored", with the ignition off, on 30 April. Further testing was immediately delayed due to the lack of control of the oil supply pressure. The oil by-pass valve in the system was modified to act as the control valve for pressure regulation, as shown in Figure 8. A nitrogen bottle was utilized as the controlled actuating pressure. This temporary arrangement required that personnel continually adjust the regulating valve throughout the test period. Further adjustments of the electrical engine control circuits canceled any additional testing until 1 May.

With the engine operating at Idle power,it was observed that the overhead light fixtures were oscillating due to the propeller air stream, including those lights that had had the extensions removed. The oil system at this power setting was maintaining the required flow rate and supply pressure, however the oil temperature at the engine pump inlet was well below the specified range of 175^{o}F to 185^{o}F. The power setting was increased slightly to approximately 1000 indicated shaft horsepower to check for any further rise in the oil supply temperature. After approximately five minutes of stabilized operation the oil temperature was still below 110^{o}F. At this time one of the ceiling-mounted light fixtures broke loose from its base and was carried by the propeller air stream to the rear of the test chamber. An abrupt engine shut-down was accomplished.

An investigation of the chamber revealed that all of the overhead lighting fixtures were damaged and would possibly fail during any additional testing. In addition the excessive heat loss in the oil supply system dictated that no further tests could be conducted until a method of heating the oil had been incorporated. The tests were therefore terminated.

It was decided on 3 May that two induction heating units available from a local contractor would be temporarily installed in "series" in the oil supply line in the test chamber. The fabrication and installation was as shown in Figure 13. Evaluation of this revised system, with the engine oil pump by-passed, revealed oil temperatures as high as 200°F. Concurrent with this modification all of the overhead light fixtures were removed from the test chamber by USNPGS personnel. All other equipment which had suffered vibration damage was re-torqued. The team from NAS Alameda was then requested to continue the acceptance test program.

Successful operation of the engine throughout its complete power spectrum was obtained on 6 May. An engine functional test was conducted and performance data were recorded. The final test was conducted with the engine operating at Military power and an acoustical survey was completed in accordance with the requirements of reference (d). The engine was removed and returned to NAS Alameda on 8 May 1964.

Test Results

The turboprop test facility acceptance test results presented below are listed according to major equipment sub-system or basic design areas defined by Appendix II, reference (d). Each area is discussed with regard to the operability, maintainability and over-all adequacy of these integral instruments in a facility designed for academic training and research investigations. Not only are the physical discrepancies presented, but also the characteristics that could negate the usefullness of this facility are itemized.

(a) Aerodynamic characteristics. Although the lack of airflow instrumentation negated any exact knowledge of the flow patterns fore and aft of the propeller; it is believed that sufficiently non-turbulent flow was available at the orifice plane. The intense buffeting and vibration that led to the damage and failure of the light fixtures and the orifice assembly were due to the normal aerodynamic loadings that prevail in an environment such as this. The use of turning vanes and flow straighteners would be desirable, but not mandatory.

As mentioned in the Test Preparation Section, the possibility of triggering the fire protection system when operating the engine in reverse pitch would have to be considered during these tests. Such a situation did develop when the engine, operating on the boundary of the reverse pitch region, created excessive temperatures in the aft chamber area due to the stagnated exhaust gases. The Cardox sensors reacted to this temperature rise and initiated the flow of CO_2 into the cell. Rapid shut-down of the engine and manually over-riding the Cardox control prevented engine damage. This incident made it evident that to completely evaluate any turboprop engine throughout its entire operating range, an engine exhaust duct must be utilized to separate the high temperature gas flow from the propeller air stream.

(b) Engine Test Data Correlation. The test data recorded during the acceptance tests agreed closely with the results displayed during the "production" test conducted earlier at NAS Alameda. Only two parameters, thrust and fuel flow, revealed excessive fluctuation during engine steady state operation which prevented an exact correlation. The variation of these two quantities is discussed further in the applicable sections below. The engine test data log is presented in Appendix IV.

(c) Engine Support Stand. The engine support stand, adapters and trunnion support mounts, shown in Figure 14 and 15, were compatible with the engine mounting dimensions and functioned satisfactorily throughout the tests. A slight modification was necessary to the overhead mount for increased rigidity, as described in the Test Preparation Section. During high power operation the engine and support stand vibrated extensively. The severity of the vibration was difficult to assess, however, gearbox vibration levels with the 150 cps filter removed were compared with the Alameda test results. The vibration of the NPGS installation was 50 mils compared to 25 mil values recorded during the earlier production run. The limit specified in reference (c) is 30 mils. A visual inspection of the welded members of the support stand and adapters revealed no structural defects due to the testing.

(d) Acoustic Survey. The inlet and exhaust acoustic installations, shown in Figure 16, performed satisfactorily. The Sound Pressure Levels recorded along a 250 foot radial arc slightly exceeded the limits specified in reference (d). The predominance of strong gusty winds contributed greatly to the SPL levels recorded. The acoustic survey of the double doors in the front of the test chamber indicated that further adjustment of the door will be required to realize the required SPL reduction of 45 db. The vibrating movement of the doors along with the centerline and especially at the center section appeared to be excessive.

After the adjustment, further tests should be conducted to verify the removal of this flexibility. The acoustic survey data are presented in Appendix V.

(e) Low Pressure Air Supply System. This air system was easily adjustable and functioned properly throughout the tests. A minor adjustment of the console operated control valve, (HC-4bv), is required to completely seal off air leakage to the engine after an engine start has been accomplished. Such a small but continual airflow could lead to a damaged engine starter.

(f) Facility Electrical System. The electrical systems, provided by the contract, were sufficient to operate the engine control systems and the console instrumentation. However, the propeller control system would have been penalized due to the lack of 208V-400 cycle power which is required to drive the propeller feather pump motor. A portable power unit was utilized during the acceptance tests as mentioned in the Test Preparation Section.

(g) Fuel Supply System. The fuel supply system functioned satisfactorily throughout the tests. However, the fuel flow indication system exhibited excessive fluctuation. Similar oscillation, observed during the turbojet test facility acceptance tests, suggest that spurious electrical noise may be filtering into these sensing systems. A check was made with the fuel lines to the engine by-passed and the facility fuel lines circulating fuel from the reservior to the flow indicators and returning to the tank. Stable flow rates were observed at the console.

(h) Oil Supply System. The problems encountered and the revisions incorporated before and during the test period were extensively covered in the Test Preparation and Test Sequence Sections. The added heat exchanger, when coupled with the engine heating effects, was sufficient to maintain the oil inlet temperature at the required level at all power settings. The electrical power required for this additional heating was approximately 22 KW. The pre-formed insulation blocks surrounding the heating unit were severely damaged due to the propeller air stream and vibration. This unit could not be utilized, without modification, for future test programs.

(i) Engine Controls. After the initial continuity checks and adjustments, the engine control systems functioned satisfactorily. Only the Time Delay Relay for the propeller control remains to be installed. This unit was not required for operation of this model of the T-56 engine.

(j) Pressure Measuring System. No major discrepancies were noted in the pressure sensing equipment. There exists an excessive error in those systems which contain chemical separators; however the contractor has furnished this activity with the necessary material (for replacing the diaphrams) and information to correct this malfunction. In order to adequately monitor oil supply pressures, it is desired that at least one pressure gauge with a 0 to 10 psi range be incorporated in the console.

(k) Temperature Measuring System. Both the high temperature system (chromel-alumel) and the low temperature unit (iron-constantine) contain built-in errors possibly due to small segment of copper leads attached to the Selector Switch on the console. The effect of this additional "cold" junction was isolated by immersing engine thermocouples in a controlled furnace and noting the actual and indicated temperatures. The data reveals that a $5^{o}F$ difference appears in the I-C system. It should be noted that both systems functioned adequately for the acceptance test purposes, but will require refinement for future research activities.

(1) Safety Hazards. In order to view the engine through the control room window, it is necessary to turn off all of the lights in the control room to eliminate excessive reflection. To illuminate the gauges on the console, a small lamp fixture was mounted on top of the console. Such a unit should be permanently attached on the control panel near the engine operator's station.

During the installation of the engine support stand and the engine, portable work platforms were utilized along both sides of the engine thrust stand, as shown in Figure 2. These units had to be partially disassembled, locked and tied together along the chamber wall during engine operation. Thus any engine adjustment during the tests required that the personnel climb the side of the engine thrust stand and the support stand. This hazardous condition should be eliminated by installation of permanently installed access platforms surrounding the thrust stand. In addition, an expanded metal grating should be placed beneath the thrust stand to protect personnel from falling objects.

There is no adequate provision to warn personnel of an impending engine start. The existing intercommunications system is not considered sufficient to alert personnel throughout the chamber area. The installation of a horn operated from the control console and the placement of warning lights at each chamber entrance would greatly contribute to the elimination of this hazard.

Conclusions

The turboprop test chamber is satisfactory for testing T-56-10W engines, if the chamber lighting fixtures are made "fail-safe" and if the oil system is modified to attain complete control of the pressure, temperature and flow rates for all ranges of engine operation. The facility should then be easily adaptable for evaluation of any turboprop engine developing up to 4500 shp.

All of the major instrumentation and control systems in the facility functioned satisfactorily. Minor modifications will be necessary to adapt to various engine types and a source of 208V-3 phase-400 cps power is required for use in the operation of T-56 engines.

The sound suppression installation meets the limits imposed in Appendix II, reference (d). Some modification will be required to the front door of the chamber to attain satisfactory Sound Pressure Level reductions.

Recommendations

It is recommended that the following items be accomplished by the contractor at no cost to the government, as soon as practicable.

1. The Temperature Trim Warning Indicator for the T-56-7 engine should be installed.

2. The two CEC Model 4-103 vibration pickups should be replaced by two Model 4-106 units; also a 15 cps filter and a 150 cps filter are required for use in the Vibration Indicator, Model No. 1-117.

3. The Low Pressure Air Supply Control Valve in the test chamber should be adjusted to eliminate the leakage.

4. The front double doors in the chamber should be adjusted or modified to realize the prescribed sound attenuation and reduce the panel deformation.

5. All of the loose fixtures in the test chamber should be re-torqued and a positive means for locking the bolts and nuts in the orifice should be incorporated.

6. The fuel flow indication system should be corrected for excessive fluctuation. The effect of other electrical systems on this system should be investigated.

7. The source of error in the temperature indicating systems should be eliminated.

8. The time delay relays specified in the G.E. drawings should be installed.

It is recommended that the following items be accomplished under an "extra work" contract as they are apparently not in the scope of the original contract. These items are required to insure safe operation of the test facility and to satisfactorily control the turbo-prop engine under investigation.

a. A source of 208V - 3 Phase - 400 cps power should be installed in the equipment room.

b. The oil system should be completely re-designed to conform to the requirements specified in the applicable NAVWEPS publications. Complete control of the system with regard to pressures, temperatures, flow rates, de-airation requirements and oil consumption checks should be made available to the engine operator in the control room. The revised system should be positioned in the original location in the equipment room. The complete heat exchanger complex required for adequate oil temperature control should also be located in the equipment room.

c. All of the overhead light fixtures in the test chamber should be replaced with "vibration-proof" units which are mounted as close to the overhead as possible. All applicable electrical conduit should be positively fastened to endure the known vibration effects.

d. An exhaust gas augmenter tube extending from the engine test stand to the chamber rear wall should be installed. An acoustic installation should be mated to this duct to insure satisfactory noise reduction at the rear of the test facility. The front of the exhaust tube should be adjustable to accomodate various engine types.

e. Work platforms and ladders should be permanently attached to the engine test stand. The platform should present no undue blockage to the propeller air stream.

f. A small light fixture should be mounted on the control console for use by the engine operator when the control room lights are off.

g. An adequate warning system should be installed to warn personnel of an impending engine start.

Appendix I

Acceptance Test Attendees

Mr. D. O'Dell	Overhaul & Repair Department, NAS Alameda
Mr. R. Paris	" " " " "
Mr. R. Wilde	" " " " "
Mr. R. Garcia	" " " " "
Mr. F. Riggs	" " " " "
Mr. J. Reilly	" " " " "
Mr. S. Walke	" " " " "
Mr. F. E. Polk	12th Naval District Public Works Office
Mr. B. L. Holt	BuWeps Fleet Readiness Representative, Pacific
Ens. A. Ferrara	Assistant ROICC- USNPGS
P. A. Abbott (ADRC)	Department of Aeronautics - USNPGS
R. Useted (ADJ1)	" " "
J. D. Dents (ADJ2)	" " "
Mr. R. E. McConnell	" " "
Mr. H. D. Hardy	" " "
Mr. W. R. Nelson	Fruin Colon Construction Company
Mr. P. L. Savage	General Electric Company
Mr. S. Fedan	Koppers Company
Mr. J. Fritz	" "
Mr. L. Sadecki	Ralph M. Parsons Company

Appendix II

List of References

(a) NAS Alameda "On-site Inspection Report", dtd., 27 Sept '63

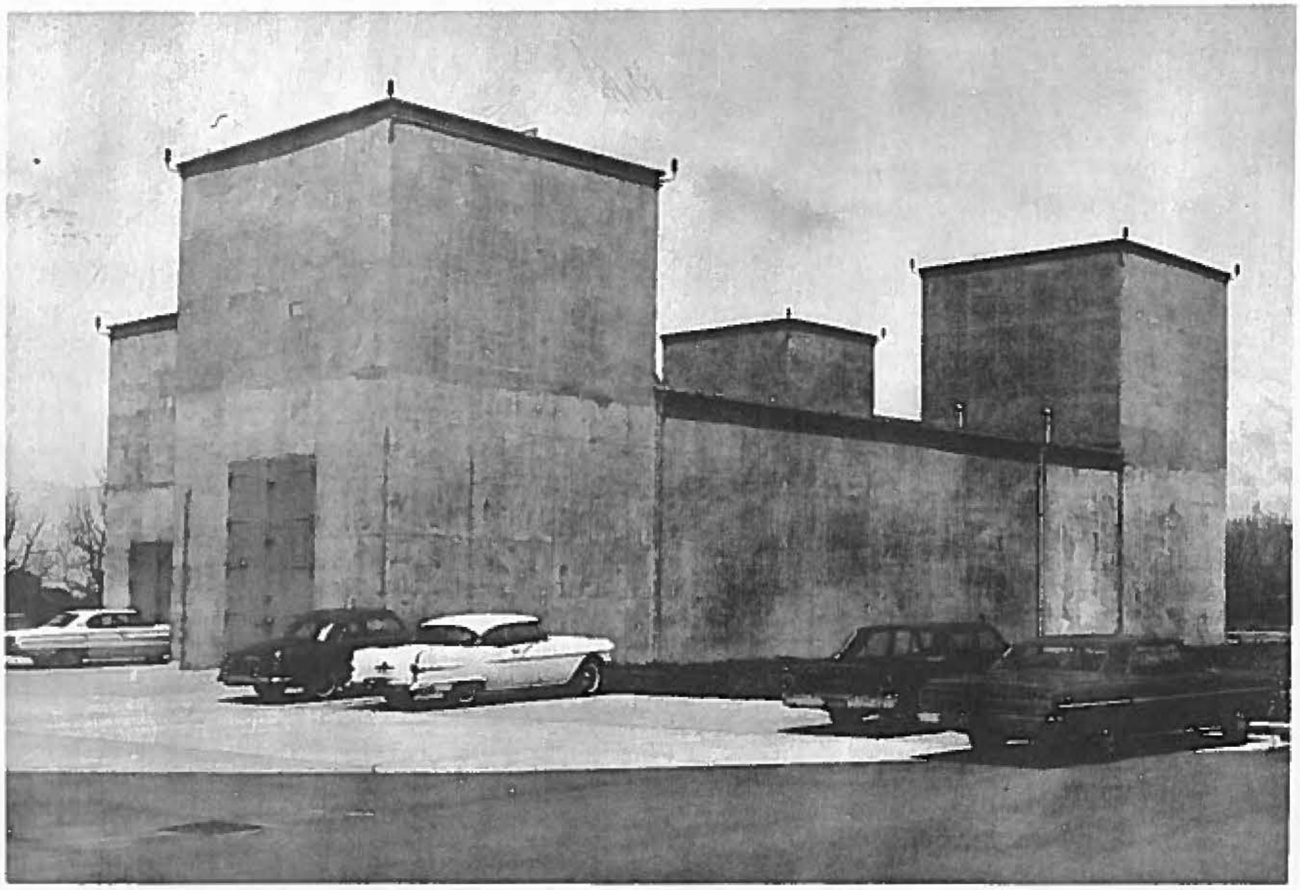
(b) NAVWEPS 02B-5DA-503, Technical Overhaul Manual (T-56)

(c) NAVWEPS 02B-5DE-3, Handbook of Overhaul Instructions (T-56)

(d) NAVDOCKS 39189/61, USNPGS Astro/Aero Propulsion Laboratory Construction Specifications with Addendum

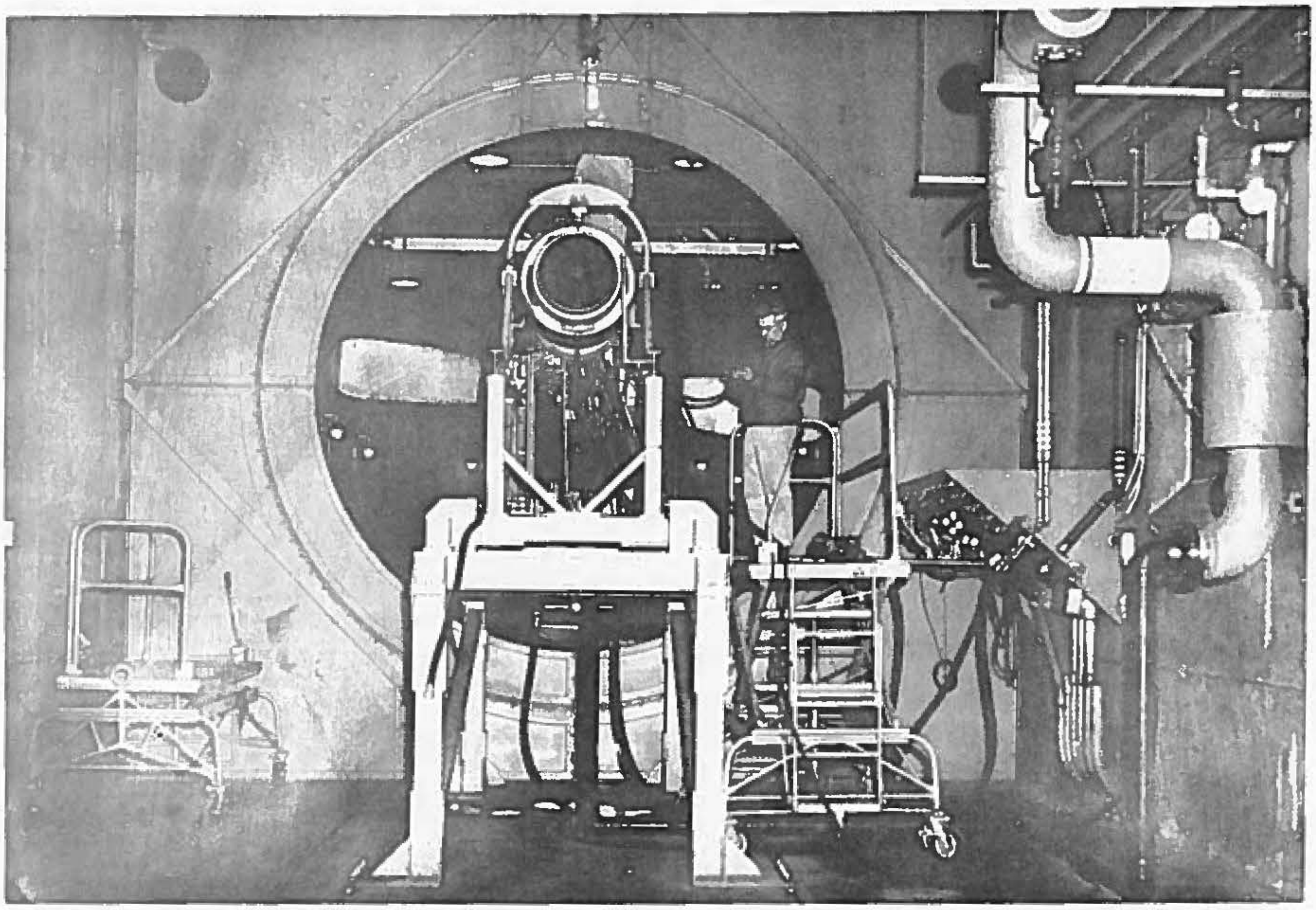
Appendix III

Photographs



Turboprop Test Facility

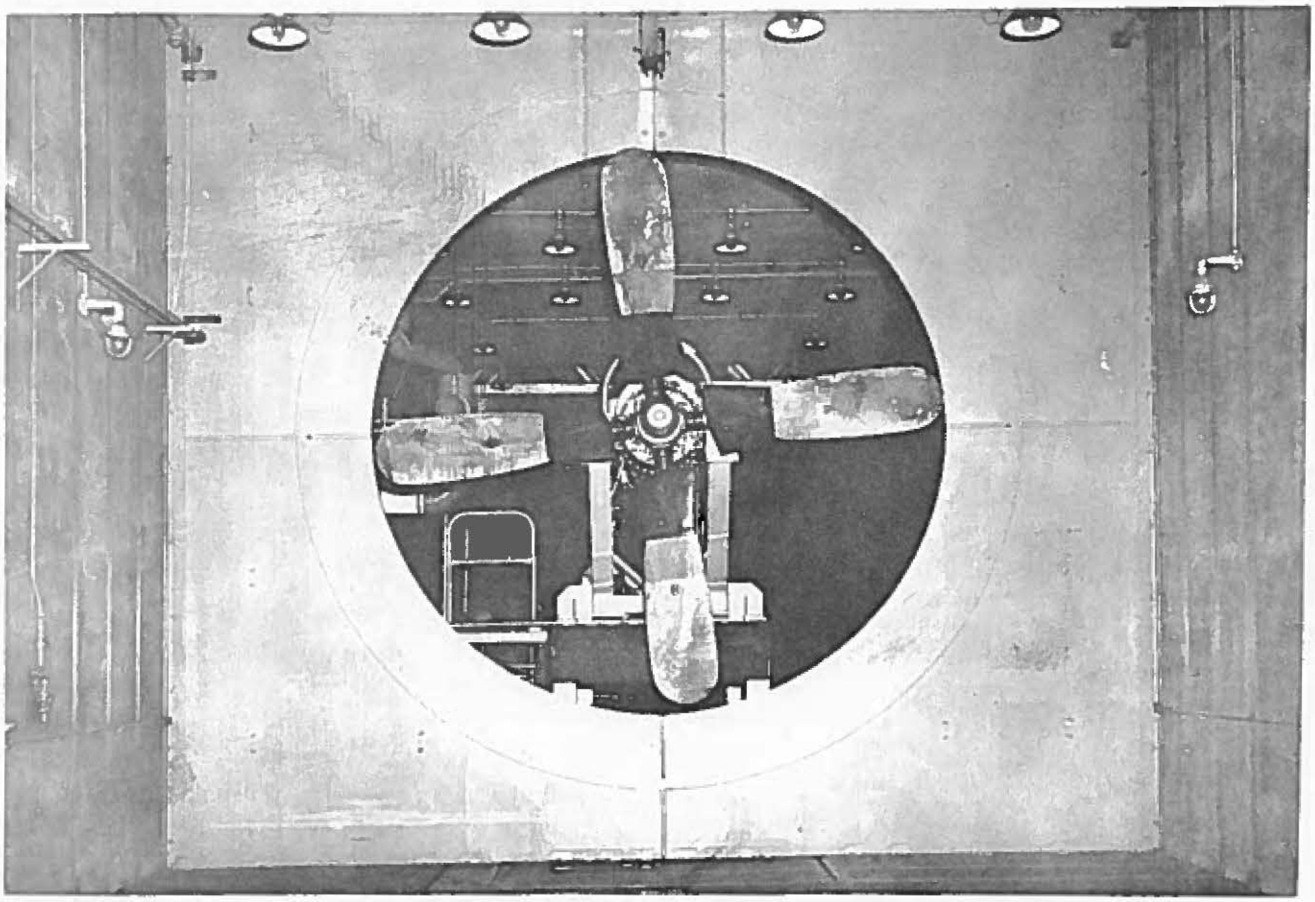
Figure No. 1



Turboprop Test Chamber

(looking forward)

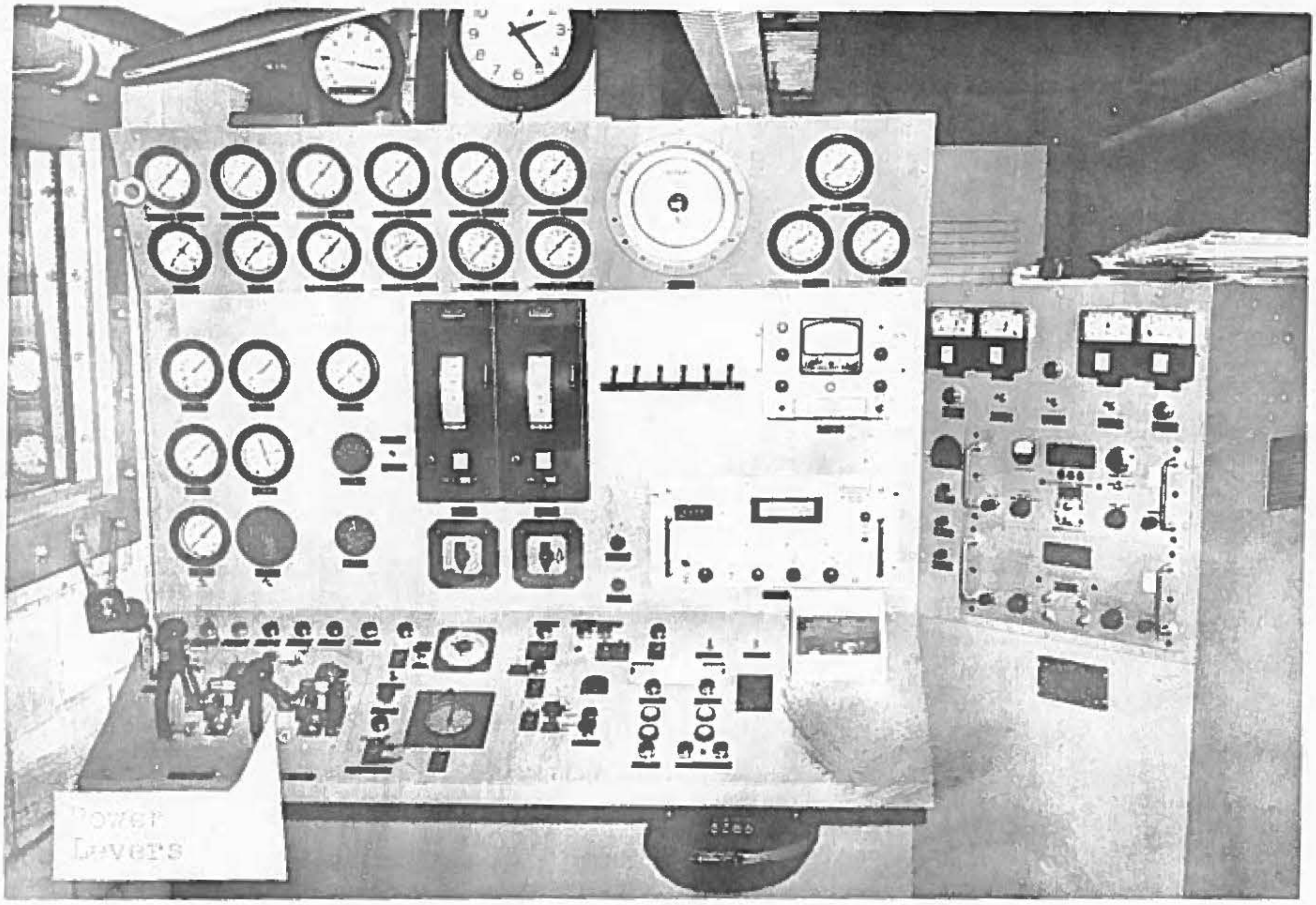
Figure No. 2



Turboprop Test Chamber

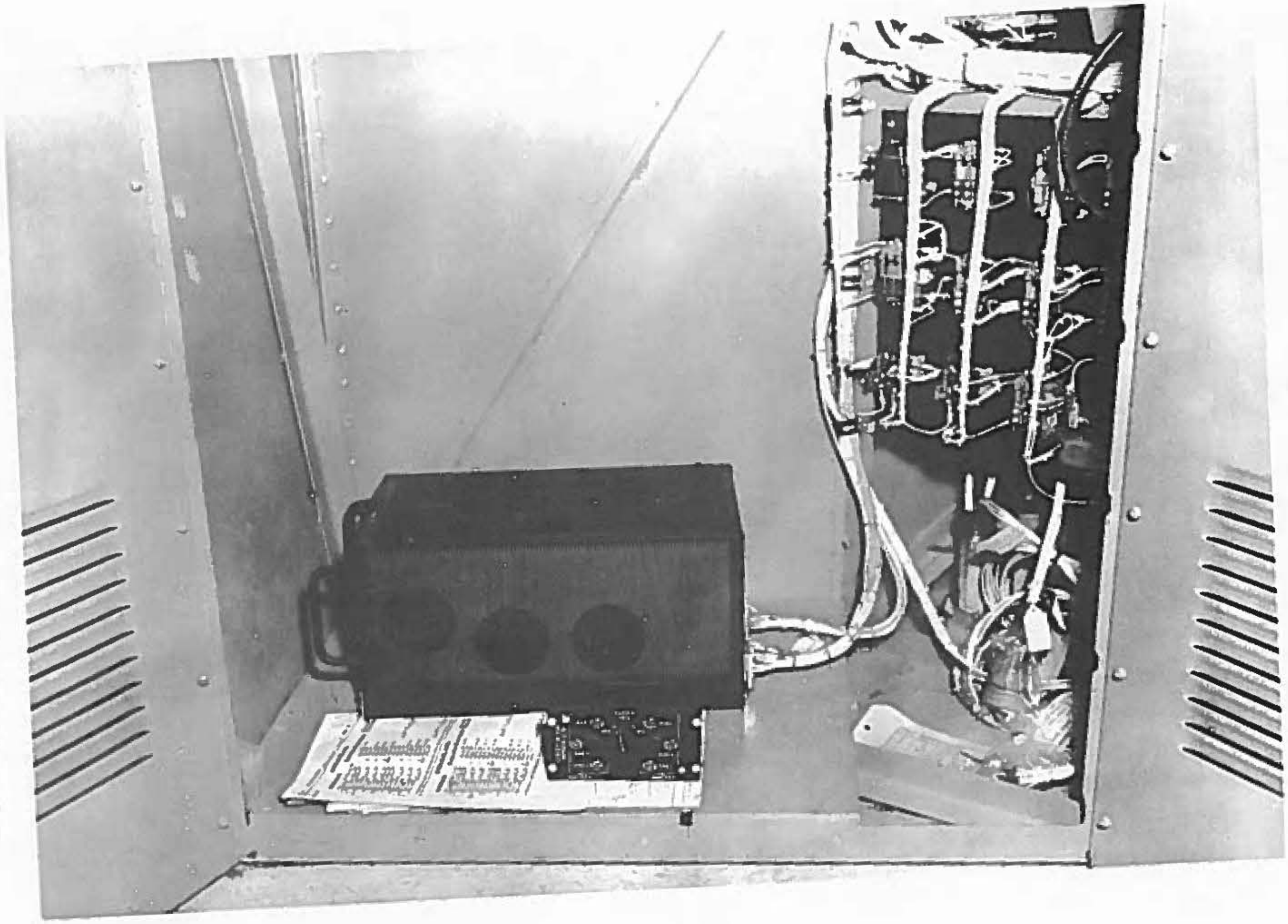
(looking aft)

Figure No. 3



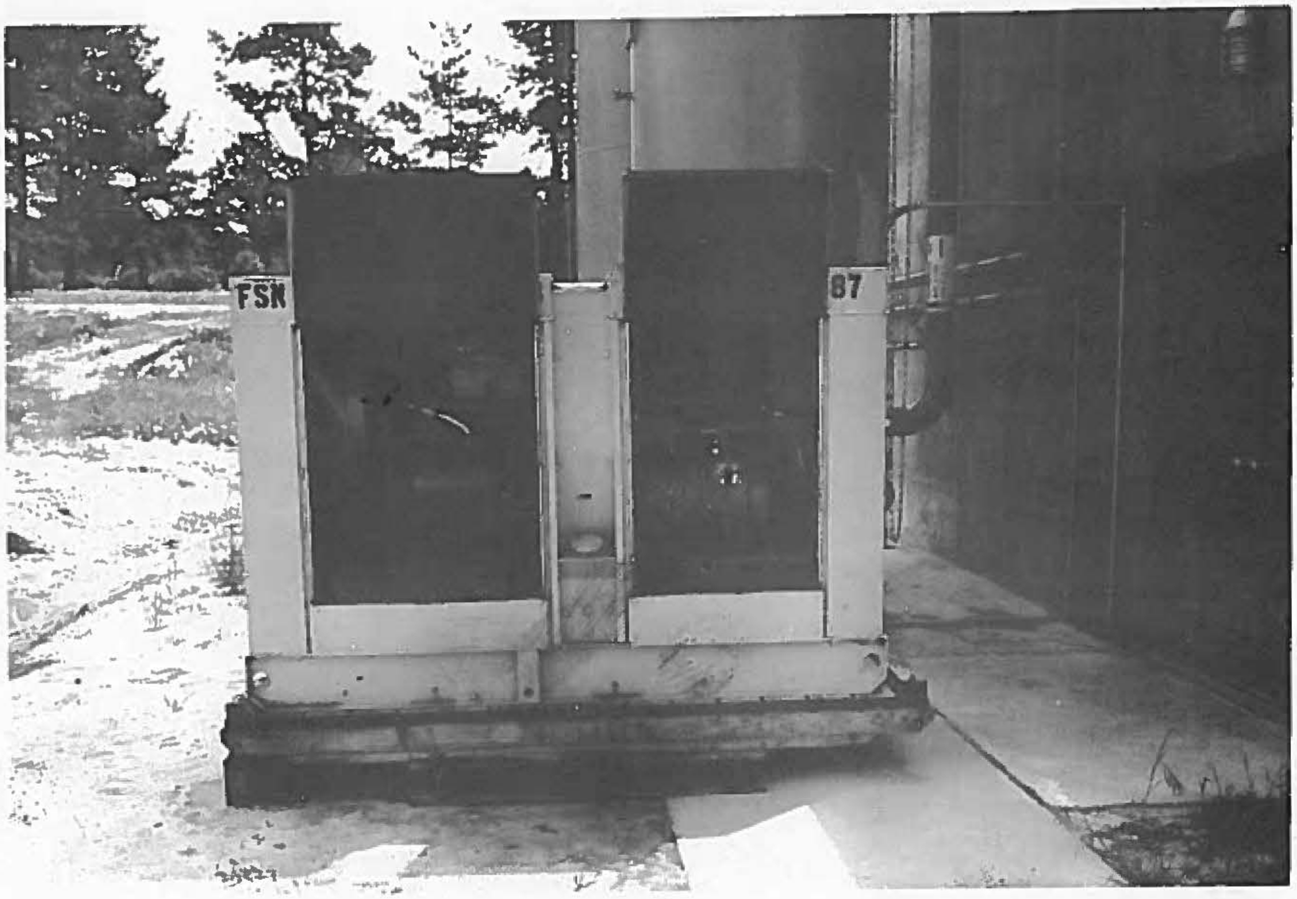
Turboprop Control Console

Figure No. 4



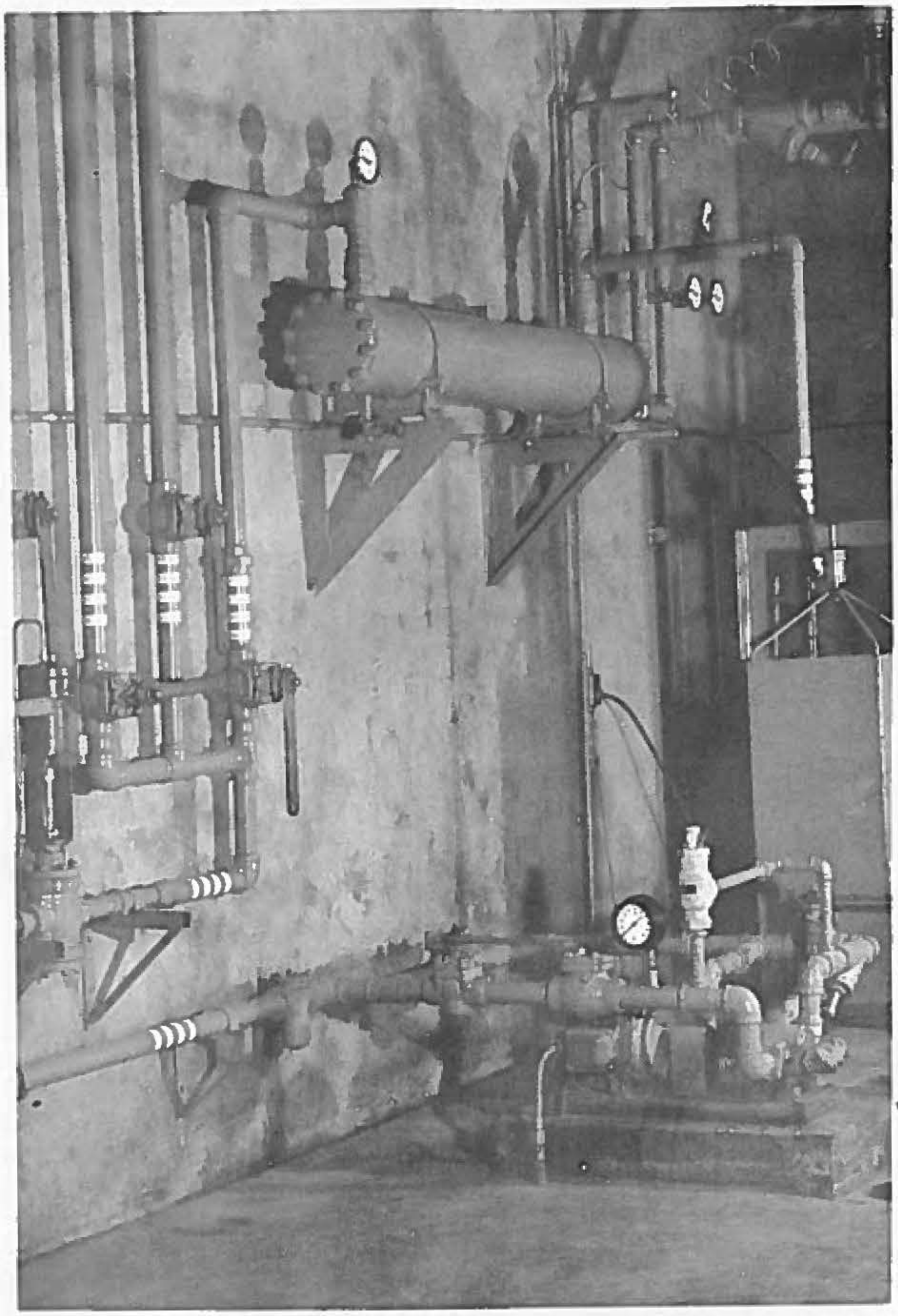
Synchrophaser and Master Trim Assembly

Figure No. 5



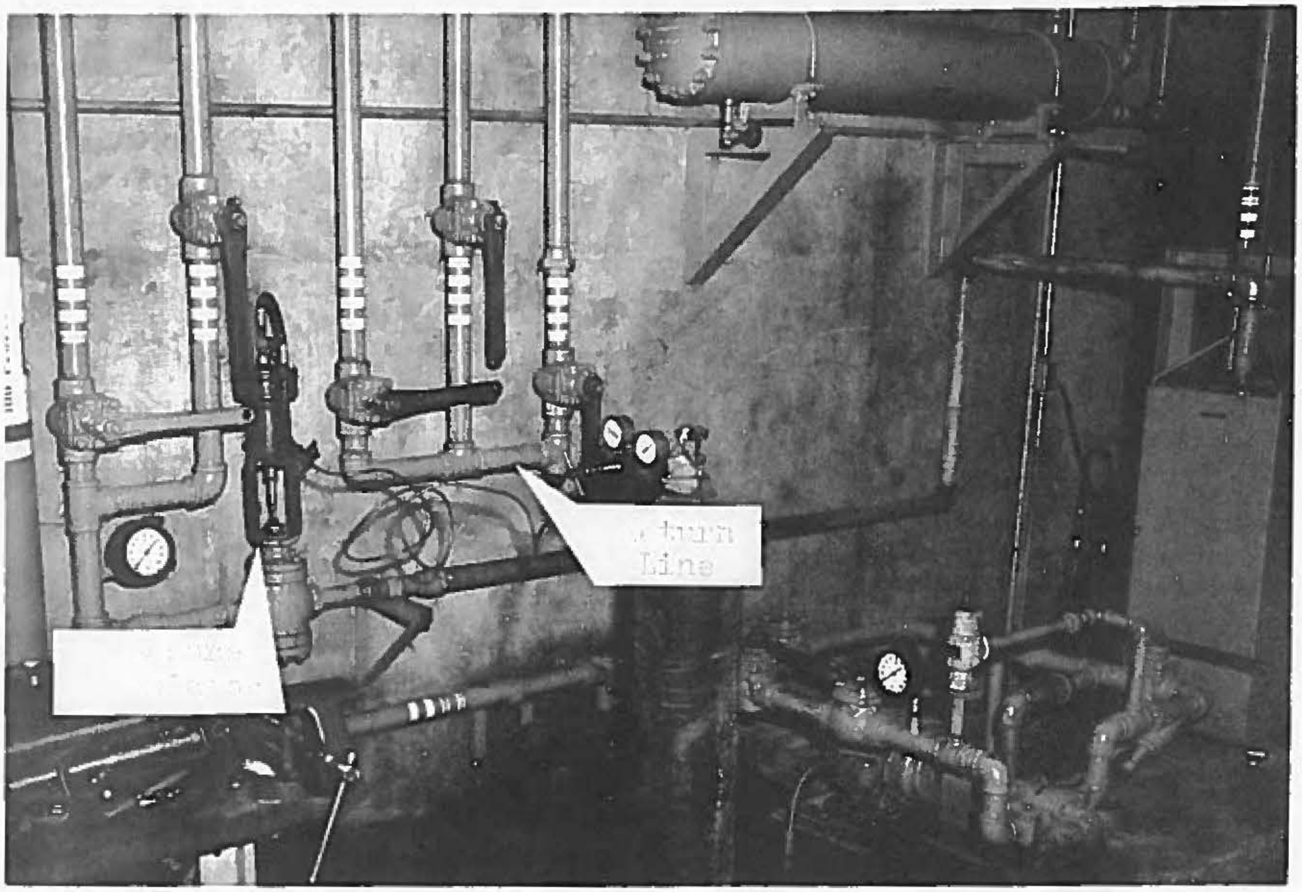
Portable Electrical Power Unit (208V-400cps)

Figure No. 6



Engine Oil Supply System
(original configuration)

Figure No. 7



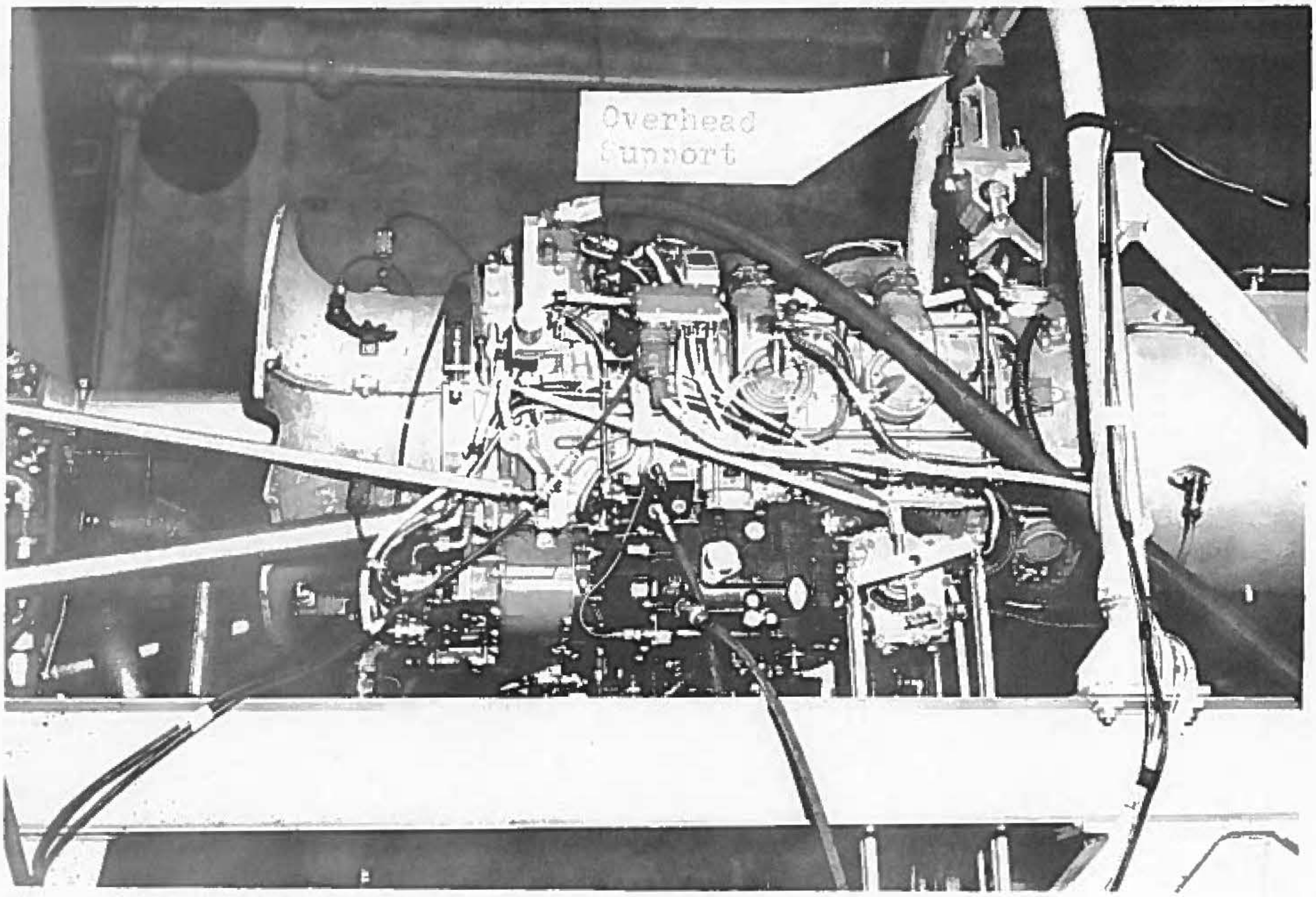
Engine Oil Supply System

(modified pressure regulator and oil return line)

Figure No. 8

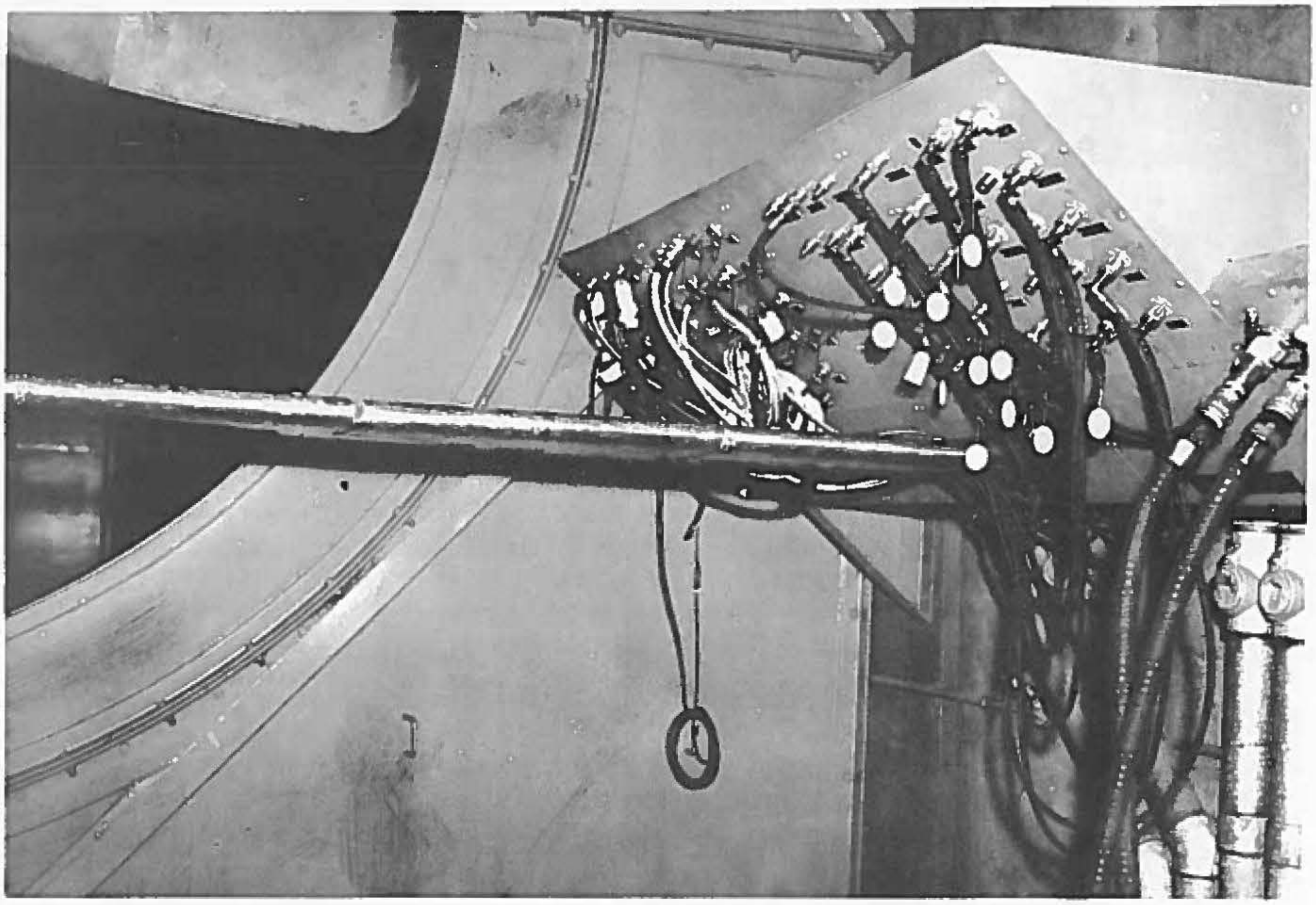
Test Chamber Lighting
Fixtures

Figure No. 9



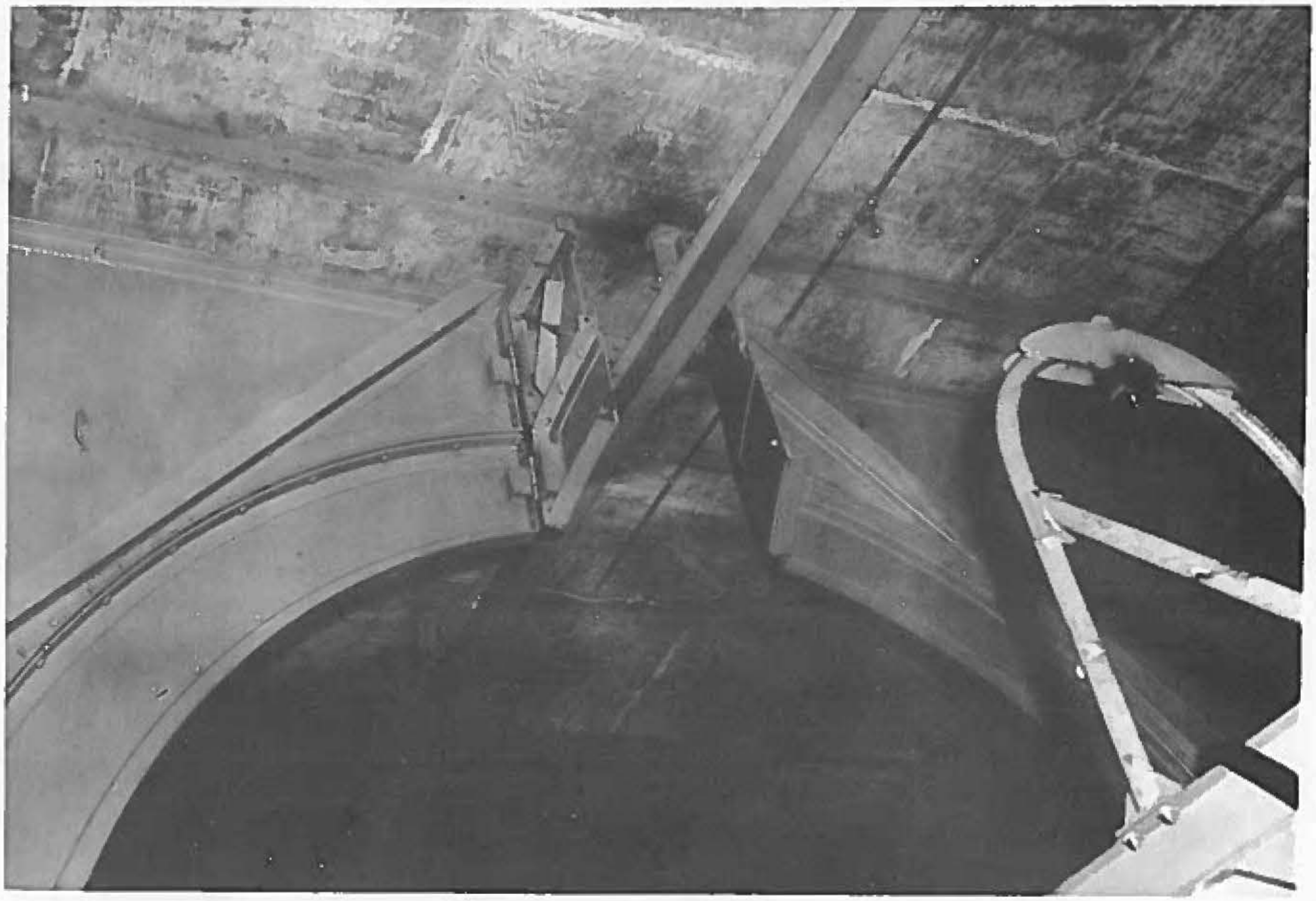
Engine Overhead Rear Support (modified)

Figure No. 10



Instrumentation Duct

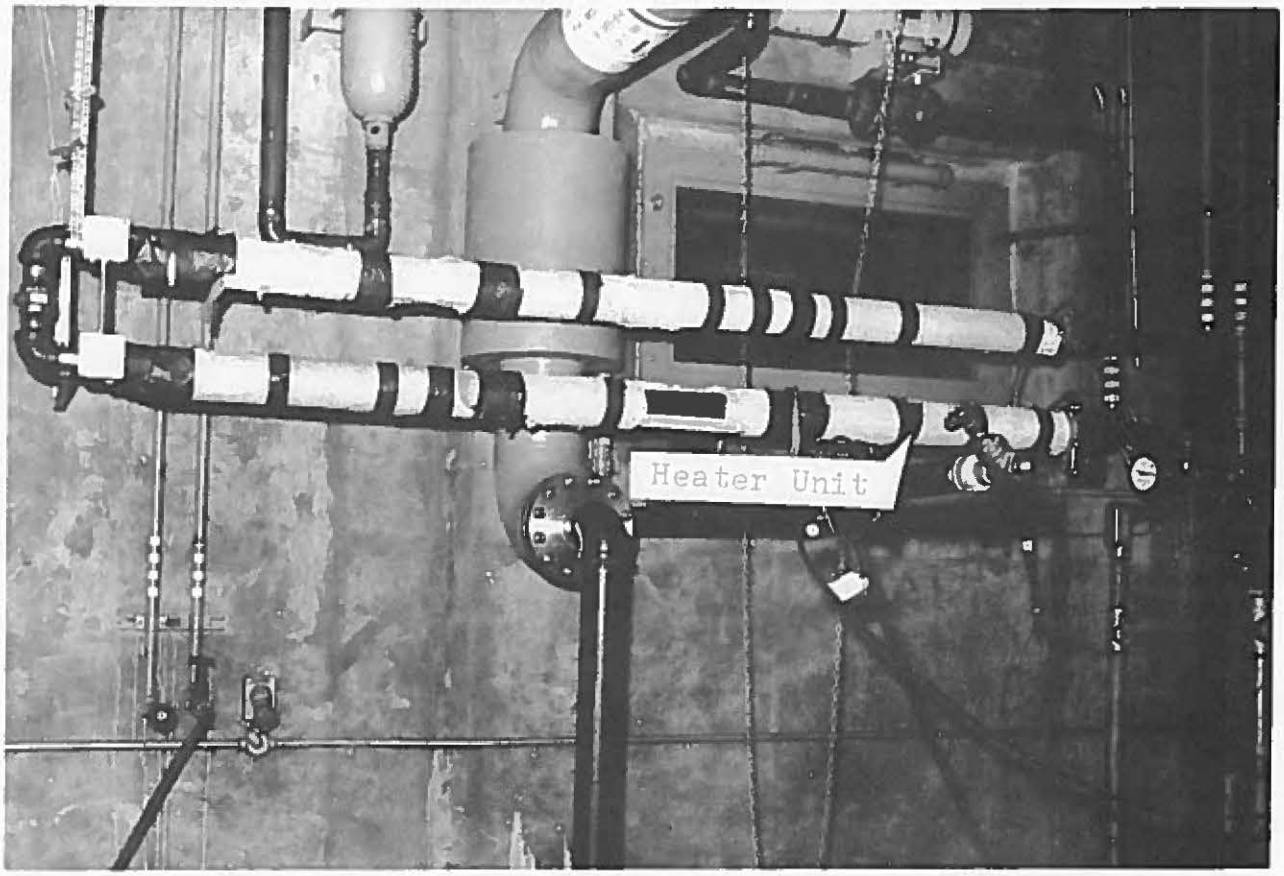
Figure No. 11



Propeller Orifice Center Panel

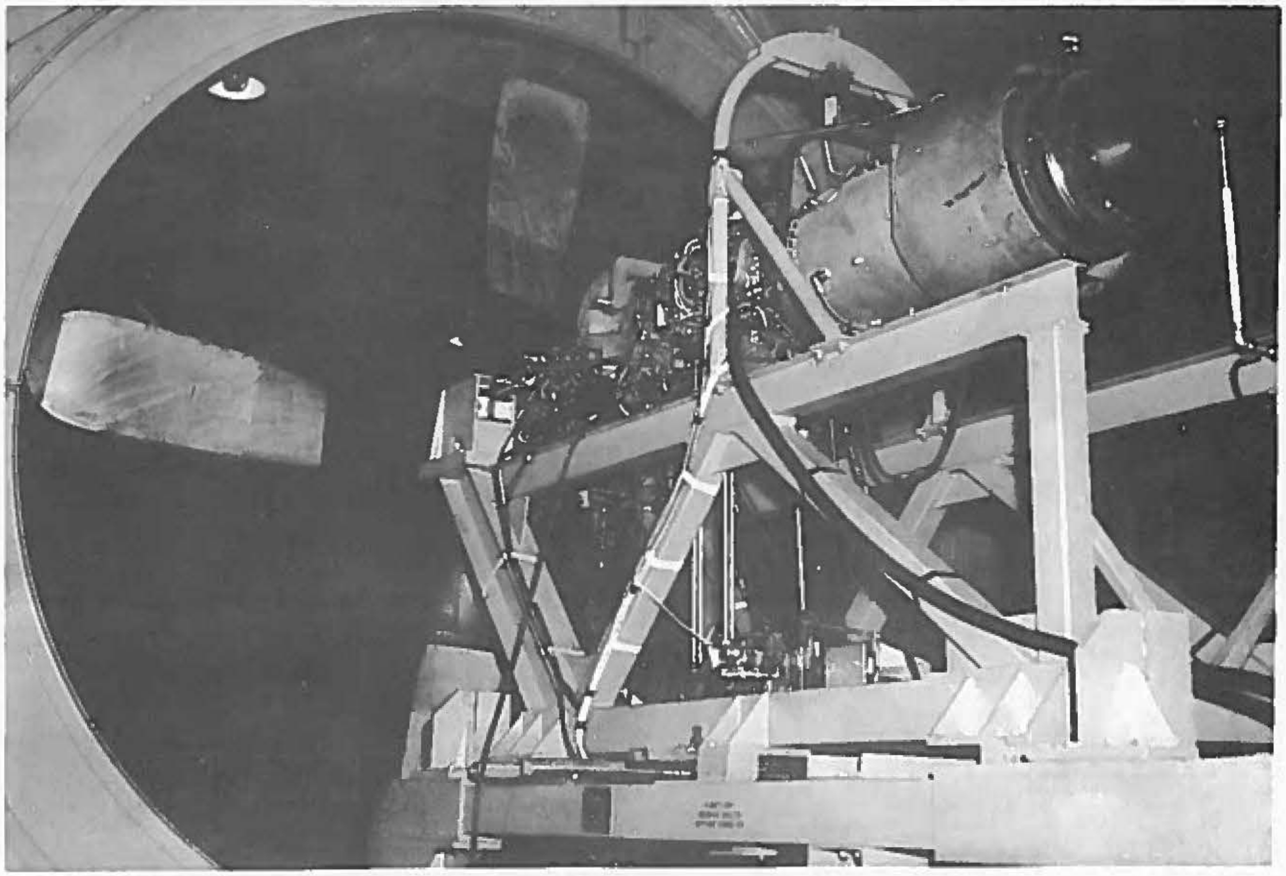
(modified)

Figure No. 12



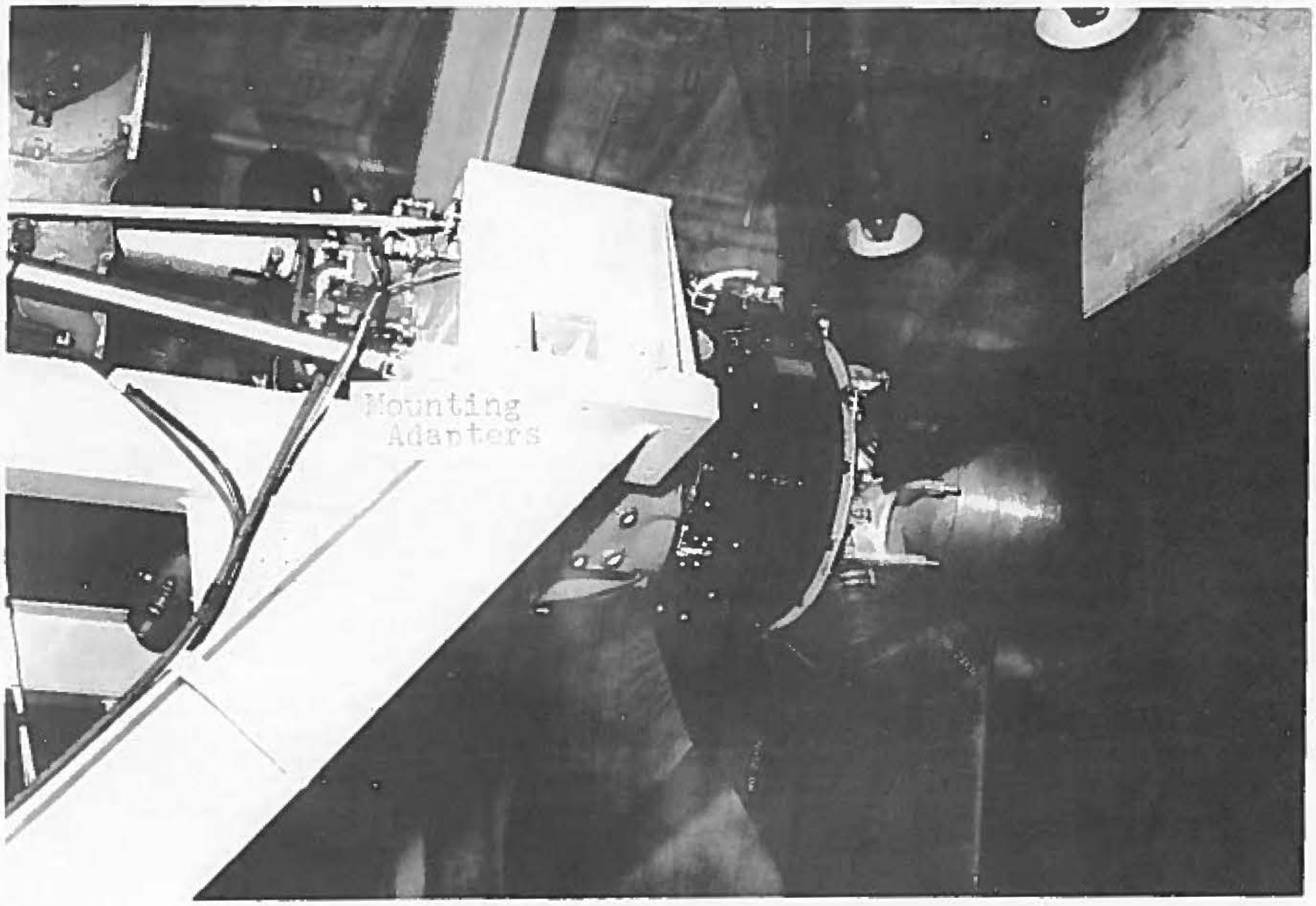
Heater Unit Added For Engine Oil Supply System

Figure No. 13



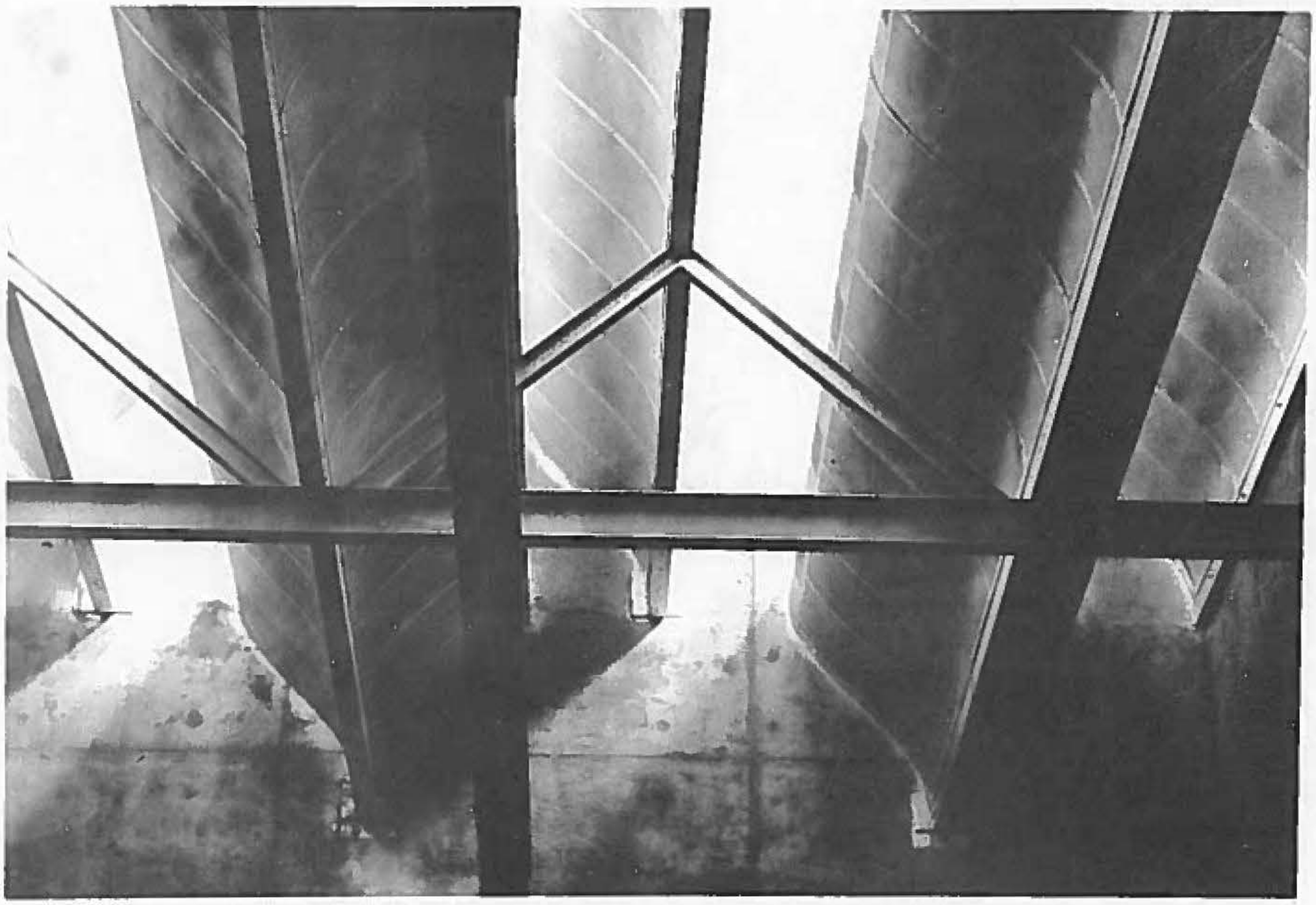
Engine Support Stand

Figure No. 14



Engine Mounting Adapters

Figure No. 15



Inlet Passage Acoustic Installation

Figure No. 16

T-56 TURBOPROP ENGINE TEST LOG

Test Location: NAS Alameda (O&R) Test Time: 1300 Test Date: 29 January 1964

Quantity	Units	1	2	3	4	5	6	7	8	9
		Engine Start: Max Temp = 1475°F	Functional Check (Fuel Governor)	Set Cal Points	Acceleration Checks (5 sec)				Reverse Pitch Check	Electrical Shutdown NTS & Prop Brake Check.
Engine Power Setting	----					Mil.	100%	75%	Rev.	
Power Lever Position	Deg			89		90	86	72	-	
Engine Speed	RPM				14700	13820	13820	13820	14340	
Turbine Inlet Temp.	°F			1780	1860	1780	1710	1505	1190	
Compressor Inlet Press.	InHgA					29.83	29.84	29.90	29.94	
Chamber Ref. Press	InHgA					30.16	30.18	30.20		
Compressor Inlet Temp.	°F					50	50	50	57	
Indicated Torque	Lb-In					18830	17350	13000		
Indicated Shaft HP	SHP					4130	3805	2851		
Minimum Allowable SHP	SHP					3925	3590	2665		
% Variance in SHP	SHP					+5.0	+7.2	+7.0		
Indicated Fuel Flow	PPH					2215	2085	1700	1095	
Actual SFC	PPH/SHP					.537	.548	.596		
Maximum Allowable SHP	PPH/SHP					.553	.569	.638		
Engine Fuel Pump Press.	PSIG					500	475	395		
Fuel Control Disch. Press.	PSIG					420	395	320		
Engine Oil Pump Press.	PSIG					57	57	57		
Engine Oil Scav. Press.	PSIG					32	32	32		
Engine Oil Inlet Temp.	°F					179	178	183		
Engine Oil Scav. Temp.	°F					242	239	238		
Gearbox Oil Pressure	PSIG					190	190	187		
Gearbox Oil Scav. Press.	PSIG					32	32	32		
Gearbox Oil Inlet Temp.	°F					183	182	186		
Gearbox Oil Scav. Temp.	°F					207	210	205		
Vibration-Compressor	Mils					.6	.5	.3		
Vibration-Gearbox	Mils					1.6	1.4	1.1		
Vibration-Turb.(150 cps)	Mils					.2	.2	.2		
Vibration-Turb. (15 cps)	Mils					3.5	3.3	5.0		

Fuel Specification: Mil-J-5624 (JP-5), Sp. Gr.-.764; Propeller Data: Hamilton Std. 54H-60-77

Gearbox S/N Ag 023478; Power Section S/N AE 103620;
Test Purpose: Production Test after Overhaul

T-56 TURBOPROP ENGINE TEST LOG

Test Location: USNPGS Monterey Test Time: 1500 Test Date: 6 May 1964

Quantity	Units	1	2	3	4	5	6	7	8	9	10	11	12
Engine Power Setting	----		LSGI							Milit	100%	75%	
Power Lever Position	Deg		17		Shutdown due to lack of oil pressure.control	Start: Check Oil Temperature Levels	Set Cal Points - Grd. Idle	Shutdown due to Chamber Lighting Failure. Oil Temperature Control N.G.	After Facility Modifications- Adjust power Lever Travel	90	86	72	Mechanical Shutdown after Acoustic Survey
Engine Speed	RPM		10420							13820	13820	13820	
Turbine Inlet Temp.	^oF		1010							1750	1690	1450	
Compressor Inlet Press.	InHgA		-							29.32	29.32	29.39	
Chamber Reference Press.	InHgA		-							29.77	29.77	29.77	
Compressor Inlet Temp.	^oF		53							52	51	51	
Indicated Torque	Lb-In		-							17800	16800	11900	
Indicated Shaft HP	SHP		-							3904	3684	2610	
Minimum Allowable SHP	SHP		-							3775	3485	2600	
% Variance in SHP			-							3.4	5.8	0.4	
Indicated Fuel Flow	PPH		-							2200	2080	1650	
Actual SFC	PPH/SHP		-							.574	.565	.633	
Maximum Allowable SFC	PPH/SHP		-							.556	.570	.648	
Engine Fuel Pump Press.	PSIG		-							475	450	380	
Fuel Control Disch Press.	PSIG		-							591	365	300	
Engine Oil Pump Press.	PSIG		55							57	57	57	
Engine Oil Scav. Press	PSIG		15							21	21	21	
Engine Oil Inlet Temp.	^oF		140							175	180	183	
Engine Oil Scav. Temp.	^oF		168							242	248	243	
Gearbox Oil Pressure	PSIG		110							185	185	182	
Gearbox Oil Scav. Press.	PSIG		17							23	23	23	
Gearbox Oil Inlet Temp.	^oF		142							177	183	185	
Gearbox Oil Scav. Temp.	^oF		153							201	205	203	
Vibration-Gearbox	Mils		.7							.3	1.0	.8	
Vibration-Compressor	Mils		.2							.5	.4	.4	
Vibration-Turb. (150 cps)	Mils		.7							.7	.5	.6	
Vibration-Turb. (15 cps)	Mils		-							3.5	2.3	3.0	

Fuel Specification: Mil-J-5624 (JP-5), Sp. Gr..764; Propeller Data: Hamilton Std. 54H-60-77
Gearbox S/N AG 023478: Power Section S/N AE 103620

Test Purpose: Acceptance Tests of USNPGS Test Facility

USNPGS Turboprop Test Facility

ACOUSTIC SURVEY RESULTS

6 May 1964 Test No. 1

Procedure: Sound Pressure Levels were recorded along a 250 foot radial arc from the subject facility centerlines. Data at seven (7) positions, $22\frac{1}{2}^{o}$ apart, were recorded while the T-56-10W turboprop engine was operated at Military power. Background noise was noted at the beginning of these tests. The facility overboard bleed air vents were closed, however the portable electrical power unit outside of the equipment room was operating throughout the tests.

Equipment:

a. Sound Level Meter, General Radio Co., Type 1551C

b. Octave Band Noise Analyzer, General Radio Co., Type 1558A

c. Sound Level Calibrator, General Radio Co., 1552A

Test Results:

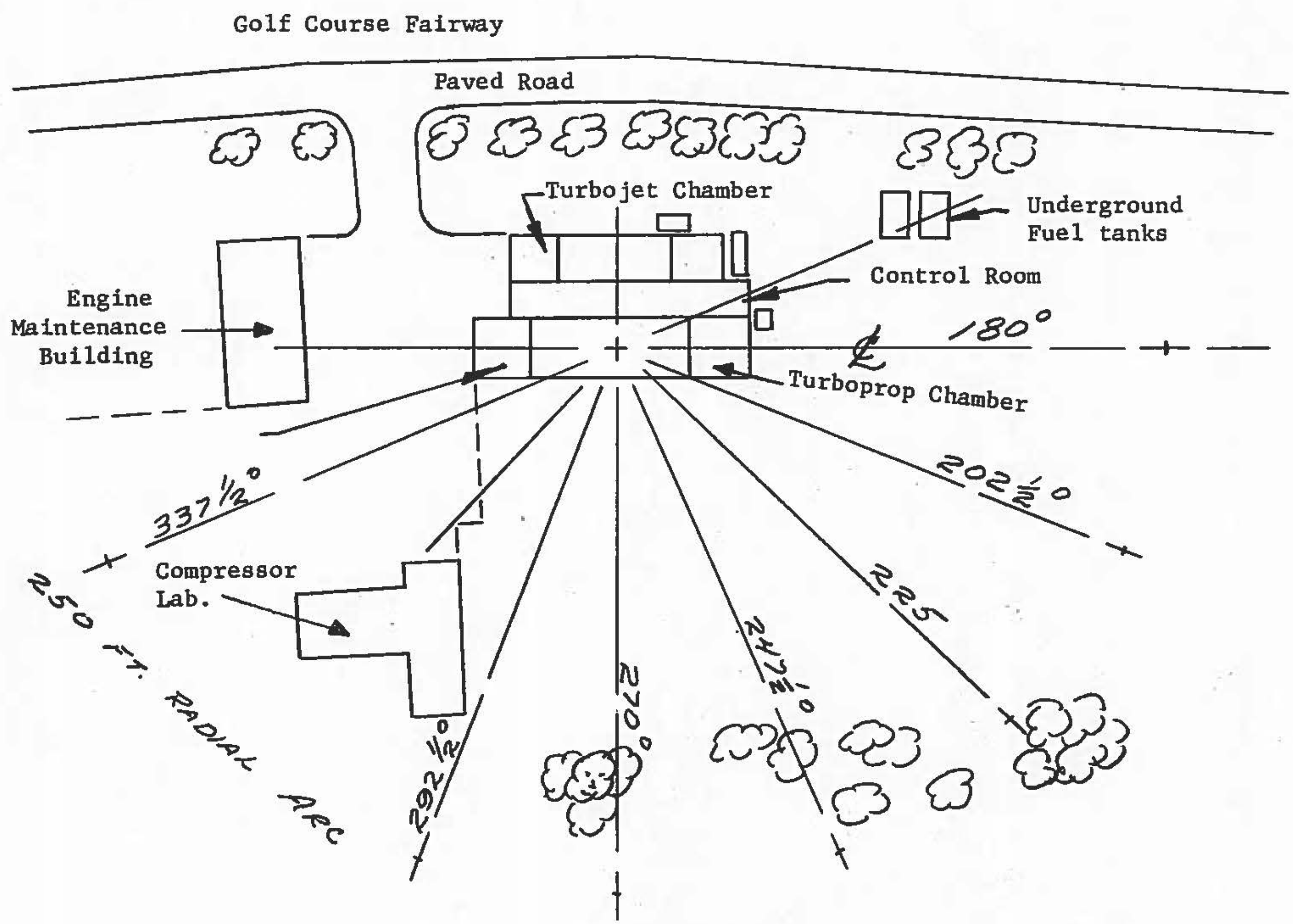
Freq. Range (cps)	Backgrd. Noise (db)	Spl Limit (db)	180	202½	225	247½	270	292½	337½
75-150	70	78	78	77	78	73	76	78	80
150-300	71	72	72	75	74	72	71	72	74
300-600	68	68	66	68	71	66	66	67	70
600-1200	67	66	66	67	68	66	64	67	68
1200-2400	69	65	67	66	64	66	65	63	67
2400-4800	67	65	64	66	71	62	63	65	67
4800-10000	68	65	60	65	66	64	66	66	64

Environment: Temperature - $56^{o}F$, Pressure - 29.860 In HgA.

Wind - 15 to 20 kts., Relative Humidity - 63%

Time - 1500 hrs.

Notes: The SPL Limit utilized is taken from NAVDOCKS 39189/61



Facility Environment Schematic

USNPGS Turboprop Test Facility

ACOUSTIC SURVEY OF THE DOUBLE DOORS
AT THE FRONT OF THE TEST CHAMBER

6 May 1964 Test No. 2

Procedure: Sound Pressure Levels were recorded on both sides of the subject door in the turboprop chamber. The survey was to determine the relative magnitude of the SPL attenuation across this component. The engine was stabilized at approximately the "cruise" power condition. Higher power settings would have introduced SPL values above the range of the instruments.

Equipment:
a. Sound Level Meter, General Radio Co., Type 1551C
b. Octave Band Noise Analyzer, General Radio Co., Type 1558A
c. Sound Level Calibrator, General Radio Co., Type 1552A

Test Results:

Freq. Range (cps)	Sound Pressure Level Inside Chamber (db)	Sound Pressure Level Outside of Chamber (at door centerline) (db)
75-150	130	100
150-300	133	102
300-600	136	104
600-1200	137	96
1200-2400	130	93
2400-4800	128	87
4800-10000	124	80
Complete Bandwidth	138/138	105

Limits: NAVDOCKS 39189/61 specifies that the acoustic doors shall reduce the SPL by no less than 45 db in the 125 to 2000 cps range.

Appendix V c